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Comparison of Two Floor Mat Lead Dust Collection Methods and Their Application in Pre-1950 and New Urban Houses

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This study investigated commercial floor mats as an alternative method to assess lead in residential dust in inner-city houses. Mats were placed for 3 weeks in interior entryways of 34 row houses built before 1950 and 17 new row houses in Baltimore City. A high volume sampler (an HVS3 floor model cyclone-based vacuum) and a hand-held portable cyclone sampler were used in the laboratory to collect side-by-side samples of mat dust. Both devices yielded comparable estimates of lead dust deposition, dust lead concentration, and dust deposition on field mat samples and had similar sampling efficiencies on mats spiked with various types of standard reference materials. The older houses had significantly higher daily lead dust deposition (GM = 130 μg/ft^2/day by HVS3) than the newer houses (GM = 9 μg/ft^2/day by HVS3), due to higher dust lead concentrations (GM = 1149 ppm vs GM = 107 ppm by HVS3) and not to differences in daily dust deposition (GM = 118 mg/ft^2/day vs GM = 87 mg/ft^2/day by HVS3). Mats were found to be a feasible method for the collection of dust that has accumulated for a known amount of time. Current wipe and vacuum methods do not allow for the estimation of dust deposition rates. Further research is needed to understand the role of floor mats as a risk assessment tool.

Introduction

This study was performed to further the examination of rubber-based carpet entryway mats as an alternative method for collecting and evaluating information on lead in residential dust. Various methods are currently employed to collect house dust. Wipe dust sampling is a commonly used method for collecting house dust for lead analysis for risk assessment, clearance testing, and research purposes (*1*). The wipe method provides estimates of dust lead loadings (mass of lead per surface area sampled). Vacuum-based cyclone devices also have been employed in research studies because they allow for estimates of dust lead concentration and total dust loading in addition to lead dust loading (*2*). These methods are typically employed to sample floor and window surfaces where dust has accumulated for an unspecified period of time. Alternatively, the placement of a new carpet mat in the home has the advantage of allowing for the collection of dust that has accumulated for a known period of time. An additional advantage is that the dust is collected from a surface that starts out in a known state of cleanliness. Analysis of mats provides estimates of the average lead deposition per area per day, the average dust deposition per area per day, and dust lead concentration. Mats placed in entryways are potentially useful in assessing the movement of lead and dust into and out of houses. The control of track-in dust can help reduce the amount of lead in dust on interior carpets and floors, thereby reducing children's exposure to lead in the home.

The main purpose of this laboratory and field-based study was to compare two cyclone-based vacuum methods for dust collection from mats. A second purpose was to compare lead and dust levels on mats placed in the interior entryways of houses in two types of urban environments, i.e., communities developed in 1997 and neighborhoods built before 1950.

Experimental Section

This study used commercially available indoor floor mats with a short pile (0.6 cm) fused to a rubber backing (TM "Floor Sentry", AKRO, Canton, OH, size: 43 × 74 cm including a 2.6 cm smooth rubber border). The same type of mat has been and is used to monitor residential lead dust deposition at the Bunker Hill Superfund Site in northern Idaho (*3*).

Mats were placed in the interior entryways of 34 scattered-site houses located in low-income neighborhoods built before 1950 in Baltimore, Md (*2*). Mats also were placed in the entryways of 17 houses located in a cluster of houses built in Baltimore in 1997. Consent for placement of the mat was obtained from participants using forms approved by the Joint Committee on Clinical Investigation of the Johns Hopkins Medical Institutions.

A new mat was placed just inside the main entrance of each study house. Main entrance was defined as the primary entryway used by the majority of residents. In all cases, it was the front entrance. The mat was oriented such that the longer side of the mat was perpendicular to the closed entryway door (i.e., portrait mode). If the mat interfered with the opening and closing of the door, the mat was moved toward the interior of the house so the door could operate. If the house had a vestibule, the mat was placed inside the vestibule. Residents were instructed not to move or clean the mat. The mat was removed after 21−23 days and placed in a cardboard transportation box large enough to hold the mat unfolded in a horizontal position. The box with the study mat inside was sealed along the edges with duct tape to avoid sample losses. Relevant field data were collected using standardized field forms.

Sampling Procedures. An HVS3 floor model vacuum device (*4*) and a hand-held Dirt Devil vacuum device as described elsewhere (*5*) were used to collect side-by-side dust samples from the mat. These two methods incorporated

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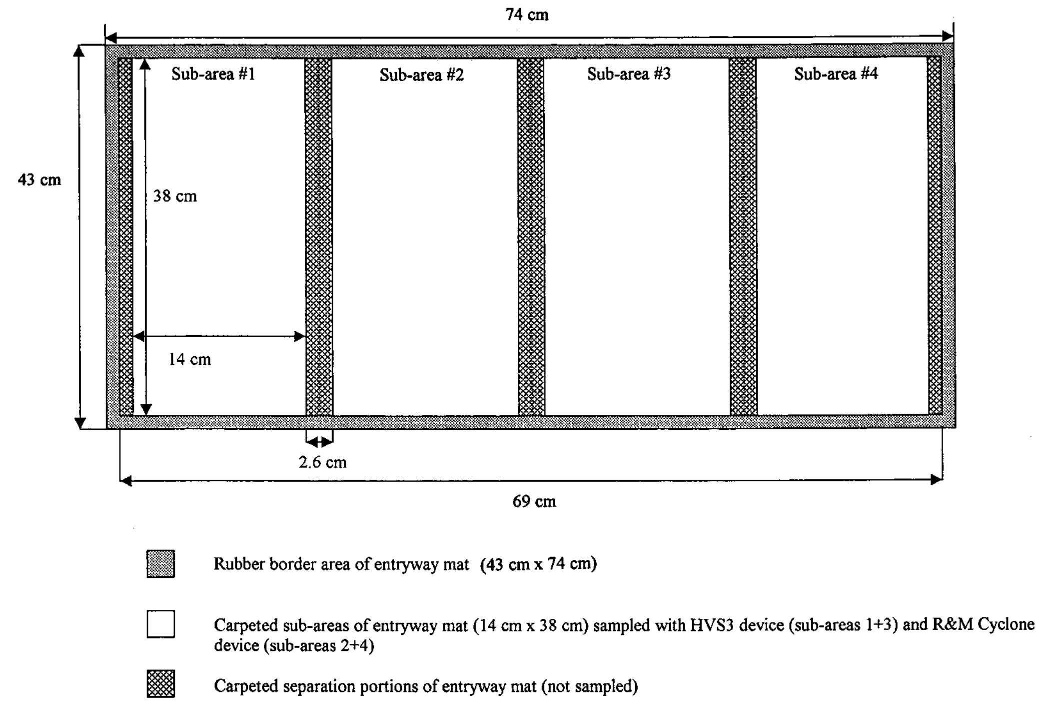

FIGURE 1. Entryway mat sampling plan.

the same high-volume cyclone dust collection device. For the purpose of this paper, these methods will be referred to as the HVS3 method and the R&M cyclone method. The latter was developed for use in the Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study (*2*).

Prior to sampling, the top half of the transportation box was removed and the mat remained in the bottom half of the box. To conduct side-by-side sampling using two sampling methods, the mat was divided into four subareas, each of size 14 × 38 cm (532 cm^2 = 0.573 ft^2) (Figure 1). The subarea width was 14 cm because the slotted HVS3 nozzle was 14 cm wide. Subareas were separated by 2.6 cm wide portions of the mat. Subareas 1 and 3 were marked for sampling by the HVS3 vacuum, and subareas 2 and 4 were marked for sampling by the R&M cyclone device. The four sides of the mat were not marked in any way that would allow for the identification of mat orientation in the house. Thus, under this sampling protocol the mat subareas selected for sampling by the two devices were random.

For sampling using the HVS3 device, a Plexiglas template (122 × 136 cm) was constructed. It consisted of two sections: the first section held the transportation box with mat, and the second section guided the movement of the HVS3 device's wheels when sampling the designated subareas. Subarea #1 was sampled for one minute. When sampling of mat subarea #1 was completed, the mat transportation box with the study mat inside was rotated 180°, so that subarea #3 was in position for sampling. The sample from subarea #3 was collected for one minute in the same container (i.e., the same microwave digestion liner attached to the cyclone) used for sample collection from subarea #1. The total time of dust collection from the two subareas was two minutes. The manometer attached to the vacuum device allowed the operator to maintain the pressure differential during the sampling at 10 in. of water.

R&M cyclone samples were collected by sampling subareas #2 and #4 of the mat for one minute each. A reusable 14 × 38 cm template was used for defining subareas for sampling using the R&M cyclone device. Dust from each subarea was collected in the same microwave digestion liner. Sampling using the R&M cyclone was conducted after the HVS3 sampling. During sampling, the mat remained in the mat transportation box in the Plexiglas template. Sampling in each subarea was done using a raster pattern according to the floor sampling protocol employed in the R&M Study (*2*).

Sample Preparation. Closed vessel nitric acid digestion in a CEM model 2100 microwave digestion system according to the SW 846 Method 3051 (*6*) was employed as the primary digestion method for mat dust samples. Nitric acid hot plate digestion according to the modified SW 846 Method 3050 (*7*) was also used for sample digestion when the amount of dust in the sample exceeded 2 g. Dust samples were not sieved prior to digestion. The following reagents were used: J. T. Baker nitric acid (trace metal grade, concentrated, 69.9–70%), Mallinckrodt AR hydrogen peroxide (30% reagent ACS), and deionized water. The volume of all reagents (including nitric acid, hydrogen peroxide and deionized water) used for hot plate digestion was increased by a factor of 3 for the high weight samples. VWR filter paper grade 410 was used for filtration.

Twelve HVS3 samples and 11 R&M cyclone samples of <1 g were digested individually as single samples using the microwave method. Ten HVS3 samples and 11 R&M cyclone samples of approximately 2 g were split in two subsamples of approximately 1 g, both of which were digested using the microwave method. Eighteen HVS3 and 18 R&M cyclone samples greater than 2 g were digested using both microwave and hotplate methods. For each of these higher weight samples, two subsamples of weight approximately 1 g were digested in the microwave system. The remainder of the sample was transferred to an 80 mL Phillips beaker and digested on a hot plate. Each subsample was analyzed separately for lead and the results were mathematically combined.

Laboratory Analysis. Digestates were analyzed by Inductively Coupled Plasma Atomic Emission Spectroscopy (Perkin-Elmer Plasma 1000) using EPA method SW 846 6010 (*8*). The following standard solutions were used for calibration (ppm): 0.25; 0.5; 1.0; 5.0; 10.0; 20.0. Standard solutions were prepared in 10% nitric acid from GFS Chemicals Lead Standard Solution (1000 ppm lead).

TABLE 1: Types of Quality Control Samples Included in the Study

QC Sample Type	Procedure
Sample Collection	
Blanks:	
mat blank	1 ft^2 of a new *Floor Sentry* mat sampled
sample collection blank	The sample collection blank sample was collected after the study mat was completely sampled and the cyclone attachments were cleaned prior to sampling the next study mat. Sample was collected by attaching a new liner to the cyclone without turning on the vacuum. This sample is the analogue to a field blank sample.
Sampling Efficiency	
Spikes with Standard Reference Materials (SRM):	
NIST SRM 2582 (nominal 0.05% lead)	0.25 g of NIST SRM 2582 embedded on 0.106 m^2 (1 ft^2) section of a new *Floor Sentry* mat
CRMO 14−050 Baghouse Dust (1914.0 ppm lead)	0.25 g of CRMO 14−050 embedded on 0.106 m^2 (1 ft^2) section of a new *Floor Sentry* mat
NIST SRM 2711 Montana soil (1162.0 ppm lead)	0.25 g of NIST SRM 2711 embedded on 0.106 m^2 (1 ft^2) section of a new *Floor Sentry* mat
Sample Preparation	
Spikes with SRMs:	
NIST SRM 2582: lead based paint (nominal 0.05% lead)	0.25 g of NIST SRM 2582 plus all reagents
CRMO 14−050 baghouse dust (1914.0 ppm lead)	0.25 g of CRMO 14-050 plus all reagents
stock solution spike	0.5 mL of Perkin-Elmer Pure Atomic Spectroscopy Standard (lead, 1000 ppm) plus all reagents.
stock solution spike duplicate	same as for the spike
reagent blank	reagents only

Quality Control. To ensure that the sampling and analytical protocols employed in the study yielded data of sufficient quality, a number of different types of QC samples were included in the study design (Table 1). The following standard reference materials (SRMs) and certified reference material were used: NIST SRM 2582 (nominal 0.05% lead); NIST SRM 2711 Montana Soil (1162.0 ppm lead); and CRMO 14-050 Baghouse Dust (1914.0 ppm lead). Stock solution spikes were prepared with Perkin-Elmer Pure Atomic Spectroscopy Standard (1000 ppm lead). The QC samples were designed to control and assess data quality in each phase of the sample collection, sample preparation, and analysis process, which were potentially subject to random and/or systematic error.

To assess background lead concentration, 10 new mats were randomly selected and sampled using the HVS3 device (Mat Blanks). A sample collection blank sample was collected (as analogues to field blank samples) after cleaning the sampling equipment and prior to collection of the next mat dust sample. Sample collection blanks were used to assess possible procedural contamination by lead (Table 1).

Mats were spiked with known amounts of standard reference materials (SRM) to assess and compare the sampling efficiencies of the two sampling devices. The QC samples used to assess sampling efficiency were prepared by applying 0.25 g of the various SRMs to a 0.106 m^2 (1 ft^2) subarea of the new mat according to the ASTM protocol F608-97 (*9*). This ASTM protocol entails the use of a roller to apply a known amount of SRM onto the mat. QC samples spiked with a known amount of SRM, and stock solution spikes were used to control sample preparation procedures (Table 1). The sample preparation QC samples were introduced directly into the digestion liners.

Data Analysis. Data analysis was performed using SPSS (version 9.0) and SAS (version 6.12) (*10*) on 111 quality control samples and 118 field samples to compare the two sampling methods. Ninety-one (91) field samples were used to compare the dust lead data between the two groups of houses.

Descriptive statistics were computed to explore the data distribution and dispersion using both QC data and field data by sample type, by dust collection method, and by house group. Paired t-tests were performed to compare differences between the HVS3 method and the R&M cyclone on the three dust endpoints for the same mat. Pearson correlation coefficients were used to assess the association between dust endpoints yielded by the two dust collection methods and ANOVA was used to compare house groups for the three endpoints. Bonferroni's test of significance was used to determine the significance of comparisons between methods and house groups for the three endpoints.

TABLE 2: Percent Recovery of Lead in Sample Preparation Quality Control Samples

QC sample type	no. samples	% recovery median	% recovery mean	s.d. %	% recovery min.	% recovery max.
NIST SRM 2582	14	88	88	4	80	96
CRMO 14-050	14	110	109	7	93	119
NIST SRM 2711	15	95	94	1	87	100
spike	14	94	94	4	87	100
spike duplicate	14	94	94	4	87	100

Results

Quality Control Samples. Descriptive statistics on lead recoveries by sample preparation QC type are displayed in Table 2. QC performance was assessed based on suitable recovery rates defined as ±20% of the "true value" and control limits defined as ±30% of the "true value". For all types of QC samples included in 14 analytical batches, the lead recoveries were within ±20% of the "true value". No differences were found between mean lead recoveries on stock solution spike and spike duplicate samples. No evidence of lead contamination was found for mat blanks, sample collection blanks, and reagent blanks; all lead values for these various types of blanks were below the instrumental detection limit (0.2 μg/mL).

Comparison of the Two Dust Collection Devices. Sampling efficiencies (percent recovery of lead in the sampling efficiency QC samples) were similar for both sample collection devices (Table 3). The mean lead recoveries for both devices were higher for NIST SRM 2582 and CRMO 14-050 than for NIST SRM 2711 (Table 3).

Table 4 displays descriptive statistics on the three dust endpoints (daily lead dust deposition, daily dust deposition,

TABLE 3: Sampling Efficiency: Percent Recovery of Lead in the Reference Materials Applied to New Mat

	no. samples		median % recovery		mean % recovery		s.d. %		min. % recovery		max. % recovery	
std reference material	HVS3	R&M	HVS3	R&M	HVS3	R&M	HVS3	R&M	HVS3	R&M	HVS3	R&M
NIST SRM 2582	9	9	80	78	80	77	14	4	64	72	108	83
CRMO 14-050	9	9	80	84	82	85	8	8	74	77	97	101
NIST SRM 2711	9	10	49	51	54	52	2	10	45	49	75	56

TABLE 4: Dust Deposition, Lead Concentration, and Lead Dust Deposition on Entryway Mats

			daily dust deposition (mg/ft²/day)			lead concentration (ppm)			daily lead dust deposition (μg/ft²/day)		
house group	sampling method	no. houses	geo. mean	range	GSD	geo. mean	range	GSD	geo. mean	range	GSD
pre-1950 Houses	HVS3	34[a]	118	7−325	78	1149	229−6620	1265	130	9−810	157
	R&M Cyclone	33[b]	100	9−289	62	1190	210−7931	1532	102	5−501	108
new urban houses	HVS3	17	84	12−192	67	107	51−199	41	9	0.9−33	9
	R&M Cyclone	7[c]	106	22−244	81	139	79−297	79	15	2−46	15

[a] Dust deposition data were available for 34 samples. One sample was lost during sample preparation; therefore, the lead concentration and lead dust deposition data are based on 33 samples. [b] Dust deposition data were available for 33 samples. One sample was lost during sample preparation; therefore, the lead concentration and lead dust deposition data are based on 32 samples. [c] Only seven mats were sampled with the R&M cyclone device.

TABLE 5: Comparison of Mean Differences between HVS3 and R&M Cyclone Lead Concentrations, Lead Dust Depositions, and Dust Depositions by House Group[a]

			mean difference			Pearson correlation	
house group	dust measure	no. samples	(HVS3 value minus R&M cyclone value)	s.d.	*t*-statistic *p*-value	coeff	*p*-value
pre-1950 houses	dust deposition	33	13.33	33	0.03	0.91	<0.001
	lead concentration	32	−32.20	374	0.63	0.98	<0.001
	lead dust deposition	32	25.07	83	0.10	0.87	<0.001
new urban houses	dust deposition	7	−0.95	41	0.95	0.87	0.01
	lead concentration	7	−28.41	75	0.35	0.33	0.44
	lead dust deposition	7	−1.67	5	0.44	0.95	<0.001

[a] When pre-1950 and new urban houses data were analyzed together, no statistically significant differences were found between HVS3 and R&M cyclone estimates of lead concentration, lead dust deposition, and dust deposition.

and dust lead concentration) for each of the dust collection devices by housing group. Differences between HVS3 and R&M cyclone estimates of lead concentrations, daily lead dust deposition, and daily dust deposition on the mats were not statistically significant, except for dust deposition in the pre-1950 houses (Table 5). When data from the pre-1950 houses and the new urban houses were analyzed together, no statistically significant differences were found between HVS3 and R&M cyclone estimates of lead concentration, daily lead dust deposition, and daily dust deposition. Estimates for each of the three endpoints in pre-1950 houses and in new urban houses based on the two dust collection devices were highly and statistically significantly correlated, except for the estimate of lead concentration in new urban houses (Table 5). Only seven new urban houses that had mats sampled using the R&M cyclone were included in the latter analysis.

Comparison of the Two Groups of Urban Houses. Using the HVS3 device, the geometric mean (GM) daily lead dust deposition on entryway mats in the new urban houses (9 μg/ft²/day) was more than 1 order of magnitude lower than the corresponding level in the pre-1950 houses (130 μg/ft²/day) (Table 4). This difference was statistically significant (t-test p-value < 0.01). Geometric mean daily dust deposition was not statistically different between the two groups of houses (84 mg/ft²/day for new urban houses and 118 mg/ft²/day for pre-1950 houses using HVS3). Geometric mean lead concentrations, however, were approximately 1 order of magnitude lower in the new urban houses than those in the pre-1950 houses (107 ppm in new houses and 1149 ppm in pre-1950 houses using HVS3). This difference was statistically significant (t-test p-value < 0.01). A similar pattern of results was found for all three endpoints based on the R&M cyclone estimates, except that the nearly 1 order of magnitude difference in mean lead concentration between the two groups of houses was not statistically significant. This is likely due to the small number ($n = 7$) of newer houses built in 1997 that had R&M cyclone measurements (Table 4).

Discussion

Comparison of Results for the Two Dust Collection Devices. This laboratory and field-based study showed that the HVS3 device and the R&M cyclone yielded comparable estimates of three mat dust endpoints. The similarity of estimates of daily lead dust depositions, dust lead concentrations, and daily dust depositions associated with the two devices is likely due to the fact that both devices employ the same cyclone. The R&M cyclone is more easily portable than the HVS3 device because it employs a hand-held Dirt Devil vacuum as the air mover. For this reason, the R&M cyclone may be used to sample mats in the field as well as in the laboratory. The larger HVS3 employs an upright vacuum cleaner and is not as well suited for sampling mats in the field. The HVS3 potentially allows for more reproducible results across studies because it has manometers for monitoring and maintaining the flow rate at a constant pressure drop during sampling. The methods require similar times for sampling and cleaning of the device between samples.

Sampling efficiencies of both devices for lead were similar and consistently higher for NIST SRM 2582 and CRMO14-

050 (mean recoveries ≥80%) than for NIST SRM 2711 (mean recoveries of 52−54%, Table 3). Since the mean lead recovery on sample preparation QC samples using SRM 2711 was 94%, the lower sampling efficiencies associated with this SRM were likely due to losses during application of this SRM to the mat and to losses during sample collection. Specifically, given the small particle sizes of SRM 2711 (<74 μm), losses may have occurred due to adhesion of SRM 2711 to the centrifuge tube used to transfer the SRM to the mat and/or to the mat fibers. Based on an analysis of the dust residue left in a sample of the centrifuge tubes, however, average lead losses during sample transfer were 3% for SRM 2711, 3% for CRMO14-050, and 17% for SRM 2582. Thus, losses due to adhesion to the mat fibers were likely to have been higher for SRM 2711 and CRMO14-050 than for SRM 2582.

We do not present data on sampling efficiency of both devices on a weight basis for the various types of QC samples or perform blank correction due to the variability of the mat blank weights and their magnitude (mean of approximately 0.1 g) in relation to the mass of SRM applied to the mat (0.25 g). Anecdotally, however, we found a pattern of lower dust recoveries for SRM 2711 than for NIST SRM 2582 and CRMO14-050 using both devices.

Our findings indicate the importance of assessing lead and dust recoveries using a variety of SRMs to identify QC sample types best suited to mat sampling and to define criteria for acceptance of mat sample collection QC values for lead analysis based on lead recoveries and/or dust recoveries. In another study (*11*), similar issues were raised with regard to the choice of QC types best suited to the analysis of wipe samples.

Differences between Houses in the Two Types of Urban Environments. Houses located in a cluster of recently constructed houses in inner-city Baltimore had a geometric mean daily lead deposition on entryway mats (9 μg/ft^2/day by HVS3) that was more than 1 order of magnitude lower than that found in houses located in urban neighborhoods built before 1950 (130 μg/ft^2/day by HVS3). This difference is due primarily to order of magnitude differences in dust lead concentration between the two groups (GM = 107 ppm in new houses versus GM = 1149 ppm in the older houses by HVS3) and not to differences in daily dust deposition (GM = 118 mg/ft^2/day in the older houses and GM = 84 mg/ft^2/day in the new houses by HVS3). Higher mat dust lead concentrations found in the pre-1950 houses is consistent with the fact that these houses are located in older neighborhoods that are more likely to contain lead-based paint on interior and exterior surfaces. Also of potential significance is the fact that these are row houses (i.e., adjoined single family houses). Because of their close proximity, the presence of deteriorated lead-based paint on a given house would likely influence the availability of lead dust that could be tracked into neighboring houses. The low mat dust lead concentrations in the newer houses are consistent with the apparent absence of lead-based paint on interior and exterior surfaces in all of the newly constructed houses in the housing complex under study. The mat findings are consistent with those of the R&M Study in that urban houses constructed before 1950 were found to have interior dust lead loadings and concentrations of lead in interior dust, entryway dust, and soil that were 1−2 orders of magnitude higher than those in houses located in clusters of urban houses built after 1979 (*2*).

Considerations for Future Studies. One type of low pile floor mat was tested in this study. This mat was selected because it is commercially available in large quantities. No effort was made to compare this mat to similar low-pile rubber-based entryway mats. We found this specific type of mat to be suitable based on size, cost, appearance, and acceptability by study participants. The disadvantage of this type of mat is that mat fibers were collected during sampling of the new mats for the mat blank samples and that larger amounts of mat fibers were observed in the field samples. We found that these mat fibers were completely digested during sample preparation; however, they may affect estimates of dust deposition and lead concentrations of low weight samples. For this reason, the identification of mats that shed a low number of fibers is an important consideration for future research. It will be useful in the future to test other types of floor mats to better understand the suitability of the mat matrix for lead analysis.

Future research also needs to compare the effectiveness of various types of mats and to test for the effect of soil and dust moisture on mat effectiveness. Deeper pile commercial grade door mats (e.g., KEX, Coral Plus, and Twister) are selected for use in the front of some stores because they clean shoes better, hold more dust and moisture, last longer, and reduce the cost of cleaning in the store compared to the low pile type of mat used in this study. The commercial grade mats might be more cost-effective in terms of reducing the time required for cleaning in the home and protecting infants and toddlers from lead in dust. Unfortunately, these higher quality mats are only available at this time by special order from mat suppliers.

Other issues that will require additional study include the duration of mat placement in houses that will yield sufficient amounts of dust for analysis and how much of the mat to sample to avoid high weight samples. In our study, mats remained in study houses an average of 21 days, and the total sample area was one square foot. Most (70%) sample weights were high (≥2 g) and required analyzing multiple subsamples of up to 1 g each. Future studies may be able to leave the mats in place for less than 3 weeks and still collect an adequate amount of dust for analysis. The rate of dust accumulation would be expected to vary based on factors such as geographical location and season. Another option would be to sample a smaller area of the mat. Little is known, however, about the distribution of dust and lead across the mat and, therefore, how to best collect a representative sample from a smaller sampling area. In future work, it would be useful to compare the three endpoints across different mat subareas (e.g., center versus periphery of the mat) to better understand the distribution of lead and dust across the mat. Another important variable in the interpretation of mat dust data is the capacity of the mat for holding dust (i.e., assessing the point at which the mat is saturated with dust).

The use of a single entryway mat in this study did not allow us to determine the predominant direction of tracking of lead onto the mat, i.e., from the inside of the house onto the mat or from the outside environment onto the mat. Multiple mats placed sequentially at the entryway of the house can contribute to a better understanding of the relative importance of interior and exterior lead sources and their pathways in different types of urban environments. An important component of future research would entail measuring the frequency of foot traffic across entryway mats and taking this into account in the interpretation of the various mat dust endpoints. The development of a reliable and cost-effective electronic method of measuring foot traffic across the mat would greatly aid this research.

It should be noted that findings of other studies suggest that the predominant direction of dust and lead movement is from the outside to the inside of a dwelling. This can be inferred from studies that have reported considerably higher surface lead loadings and/or lead concentrations from exterior dust samples compared to interior floor dust measurements (*2, 12, 13*). This inference is also supported by reports of higher dust lead loadings from interior floor samples collected near the main entrance of the houses compared to floor dust samples from other areas of the home (*12*). Further support is provided by the work of Roberts et al. who reported that more than 90% of processed street dust applied to the sole of a shoe was removed after two steps on plush carpeting (*14*).

Due to the relatively small number of study houses, estimates for the three dust endpoints provided in this report are not generalizable to Baltimore City or to other cities, communities, and other types of housing and urban environments. It will be important to conduct additional studies in a variety of urban environments to gain better estimates of mat dust lead levels and the predominant direction of tracking of lead and dust.

It also will be important to investigate the relationship between mat dust endpoints and data from the same house on dust lead loadings, lead concentrations, and dust loadings provided by commonly used sampling methods (e.g., wipe and cyclone samples) on a variety of interior and exterior surfaces (e.g., floors, window sills, interior and exterior entryways, and sidewalks). It will be particularly important to relate mat dust endpoints to wipe and cyclone endpoints that have been shown to be correlated to children's blood lead concentrations (e.g., floor and window sill lead loadings) (*15*) and to relate mat endpoints directly to children's blood lead concentrations. This will further our understanding of the role of floor mats as a new risk assessment tool in relation to well-established dust collection methods for lead analysis.

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